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(54) **Rotary internal combustion engine**

(57) A rotary internal combustion engine includes an engine block (20) defining a cylindrical inner space (22) in which a toothed ring portion 20(a) is integrally attached with the engine block (20). A cylindrical block (40) is rotatably fitted in the cylindrical inner space and defines a number of cylinder bores (48) therein to each receive a piston (60) which is pivotally attached with a connecting rod (50) which is pivotally connected with a crank (52) which is coaxially and fixedly connected with a pinion (80) meshing with the toothed ring portion. A number of spark plugs (30) are installed on the engine block (20) at angular intervals. The piston may conduct reciprocal movement and thus the pinion may be driven into rotation so that the cylindrical block and an output axle (100) are rotate corresponding to the engine block.

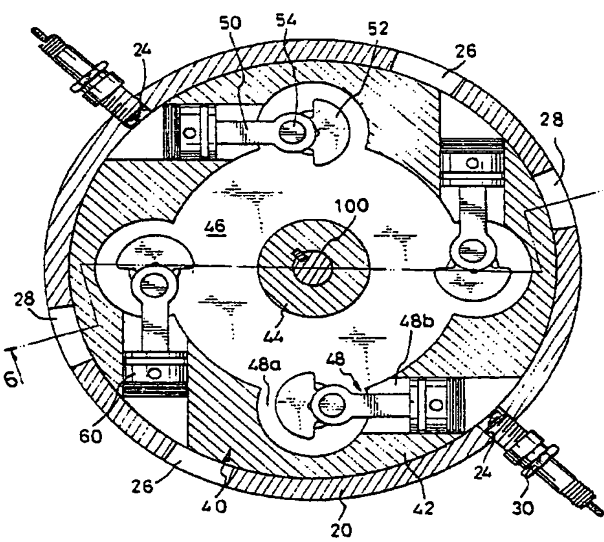

FIG. 1

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Description

[0001] The present invention relates to a rotary internal combustion engine, and more particularly to a rotary internal combustion engine that can be fabricated in a small size and/or light weight for saving fuel without compromising the structural strength.

[0002] During the history of automotive engines, many proposals have been made to replace the conventional reciprocating motion of a piston with a rotary motion of a piston, however they have almost all been rejected. It was not until the late 1950s that rotary piston engine theory began to be successfully translated into practice, as exemplified by the Wankel engine. Even so the only company now making a production Wankel engined car is the Japanese manufacturer of Mazda cars, although engines operating on the Wankel principle may be found in other transportation and industrial applications. Although the Wankel engine has the claimed advantages that it occupies less space and offers a reduction in weight relative to its power output, it compromises the combustion efficiency since the moving combustion space of this type of engine lacks compactness.

[0003] Another type of rotary engine is the gas-turbine engine, which has been successfully fitted in airplanes, helicopters, ships and electric generating systems. As to this type of engine, it operates mostly at a constant speed, so that it does not perform well in automotive vehicles. Another reason for this unsuitable performance is a noticeable delay in acceleration after the driver has depressed the throttle. Also, the power-turbine section, which gets very hot and runs at a very high speed, is made of expensive materials. This makes the gas-turbine engine fabrication cost much more than a comparable piston engine, and as a result there is no gas-turbine commercially available for cars.

[0004] In view of the foregoing, the applicant has invented a rotary internal combustion engine, which has the advantage of space and/or weight reduction without compromising the combustion efficiency as exists in the Wankel engine.

[0005] The primary object of the present invention is to provide a rotary internal combustion engine, which comprises an engine block and a cylindrical block. The engine block defines a cylindrical inner space in which a toothed ring portion is integrally attached with the engine block. The engine block is connected with an output axle. The engine block is installed with a plurality of spark plugs and defines a plurality of exhaust ports and a plurality of intake ports communicating with the cylindrical inner space. The cylindrical block is rotatably and snugly fitted in the cylindrical inner space of the engine block. The cylindrical block defines a plurality of cylinder bores therein along a circumferential portion thereof to each receive a piston therein. Each cylinder bore is accessible to the spark plug, the exhaust ports, and the intake ports upon rotation of the cylindrical block. The piston is pivotally attached with a connecting rod which is pivotally connected with a crank which is coaxially and pivotally connected with a pinion which in turn meshes with the toothed ring portion of the engine block. In such an arrangement, each piston is allowed to conduct reciprocal movement action including a power stroke movement, an exhaust movement, an intake movement, and a compression stroke movement, along the respective cylinder, which in turn drives the crank to rotate integrally with the pinion through the connecting rod, which in turn drives the cylindrical block to rotate integrally with the output shaft connected thereto. Thus, the rotation of the pinion may cause the cylindrical block together with the output axle to rotate with respect to the engine block to supply a rotational mechanical power output drive.

[0006] Another object of the present invention is to provide a rotary internal combustion engine, which comprises an engine block, a cylindrical block, a plurality of pistons, and a plurality of pinions. The engine block defines a cylindrical inner space in which a central toothed ring portion is integrally attached with the engine block, a plurality of exhaust ports, and a plurality of intake ports. The plurality of threaded holes are evenly distributed along a periphery of the engine block and communicate with the cylindrical space to respectively receive a spark plug therein. The plurality of intake ports are evenly distributed along the periphery of the engine block respectively corresponding to the plurality of spark plugs. The plurality of intake ports are evenly distributed along the periphery of the engine block respectively corresponding to the plurality of the spark plugs. Each exhaust port is arranged at a position following one of the spark plugs whilst each intake port is arranged at a position following one of the exhaust ports and thus is adjacent to a subsequent spark plug. The cylindrical block is rotatably and snugly fitted in the cylindrical inner space of the engine block. The cylindrical block has a circumferential portion and a central hub portion connected with an output axle and thus defines a ring-shaped recess between the central hub portion and the circumferential portion. The circumferential portion of the cylindrical block defines a plurality of chambers evenly distributed therealong. Each chamber includes a crank-receiving space portion and a cylinder bore portion communicating with the crank-receiving space portion. The plurality of pistons, which are each pivotally attached with a respective connecting rod, are respectively installed in the cylinder bore portions of the chambers. Each connecting rod is pivotally connected with a crank via a crankpin mounted in the respective crank-receiving space portion above a bottom portion of the cylindrical block which defines the ring-shaped recess and each crank-receiving space portion. The plurality of pinions are each coaxially and fixedly mounted with the respective crank via a stub. The pinions are each located below the bottom portion of the cylindrical block to mesh with the central toothed ring portion attached with the engine block. In such an

arrangement, each piston is allowed to conduct reciprocal movement action including a power stroke movement, an exhaust stroke movement, an intake stroke movement, and a compression stroke movement, which in turn drives the respective crank to rotate integrally with the respective pinion through the respective connecting rod, which in turn drives the cylindrical block to rotate integrally with the output axle. Thus, the rotation of the pinions causes the cylindrical block together with the output axle to rotate with respect to the engine block to supply a rotational mechanical power output.

[0007] Other novel features and advantages of the invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

IN THE DRAWINGS:

[0008]

FIG. 1 is a schematic sectional view of a rotary internal combustion engine in accordance with the present invention, in which a cylindrical block thereof is at a first position.

FIG. 2 is a schematic sectional view of the rotary internal combustion engine in which the cylindrical block thereof is at a second position.

FIG. 3 is a schematic sectional view of the rotary internal combustion engine in which the cylindrical block thereof is at a third position.

FIG. 4 is a schematic sectional view of the rotary internal combustion engine in which the cylindrical block is at a fourth position.

FIG. 5 is a schematic sectional view of the rotary internal combustion engine in which the cylindrical block is at a fifth position.

FIG. 6 is a cross-sectional view of the rotary internal combustion engine taken along line 6-6 of FIG. 1.

FIG. 7 is a partially exploded view of the rotary internal combustion engine piston assembly.

FIG. 8 is a schematic sectional view of the rotary internal combustion engine in which a toothed ring portion of an engine block is in mesh with a plurality of pinions.

FIG. 9 is a modified embodiment of the rotary internal combustion engine in accordance with the present invention.

FIG. 10 is a second modified embodiment of the rotary internal combustion engine in accordance with the present invention.

FIG. 11 is a typical timing diagram illustrating the operating process of the present invention.

[0009] Referring to FIGS. 1, 6 and 8, a rotary internal combustion engine in accordance with the present invention comprises an engine block 20, a cylindrical block 40, a plurality of pistons 60 (the figure showing 4 pistons), and a plurality of pinions 80 (see FIGS. 6 and 8). The engine block 20 defines a cylindrical inner space 22 (see FIG. 6), a plurality of threaded holes 24, exhaust ports 26, and intake ports 28. Typically, the quantity of the spark plugs 30, the quantity of the intake ports 28, and the quantity of the exhaust ports 26 are the same, the quantity of either of which is half of the quantity of the pistons 60.

[0010] The engine block 20 is integrally attached with a central toothed ring portion 20a in the cylinder space 22 of the engine block 20. The plurality of threaded holes 24, each of which communicates with the cylindrical inner space 22, are distributed along a periphery of the engine block 20 to respectively receive a spark plug 30 therein. The plurality of exhaust ports 26, respectively corresponding to the plurality of spark plugs 30, are evenly distributed along the periphery of the engine block 20. The plurality of intake ports 28, respectively corresponding to the spark plugs 30, are also evenly distributed along the periphery of the engine block 20. As can be seen in FIG. 1, each exhaust port 26 is arranged at a position following one of the plurality of spark plugs 30 whilst each intake port 28 is arranged at a position following one of the plurality of exhaust ports 26 and thus is adjacent to a subsequent spark plug 30. Typically, the angular distance between a spark plug 30 and a following exhaust port 26 is substantially twice of the angular distance between the said following exhaust 26 and a following intake port 28, and substantially equals the angular distance between the said following intake port 28 and a subsequent spark plug 30 following the said following intake port 28 (see FIG. 11).

[0011] The cylindrical block 40, which is rotatably and snugly fitted in the cylindrical inner space 22 of the engine block 20, has a circumferential portion 42 and a central hub portion 44 connected with an output axle 100 and thus defines a ring-shaped recess 46 between the central hub portion 44 and the circumferential portion 42 of the cylindrical block 40. The circumferential portion 42 of the cylindrical block 40 defines a plurality of chambers 48 evenly distributed therealong, each chamber 48 including a crank-receiving space portion 48a and a cylinder bore portion 48b communicating with the crank-receiving space portion 48a (see FIG. 1).

[0012] The plurality of pistons 60, each of which is pivotally attached with a connecting rod 50, are respectively installed in the cylinder bore portions 48b of the chambers 48, wherein each connecting rod 50 is pivotally connected with a crank 52 via a crankpin 54 mounted in a respective crank-receiving space portion 48a above a bottom portion 40a of the cylindrical block 40, which defines the ring-shaped recess 46 and each crank-receiving space portion 48a (see FIGS 1 and 6).

[0013] Referring to FIGS. 6, 7 and 8, the plurality of pinions 80 are each coaxially and fixedly mounted with a crank 52 by a pin 56. The pinions 80 are each below the bottom portion 40a of the cylindrical block to mesh with the central toothed ring portion 20a attached inte-

grally with the engine block 20.

[0014] In operation, the pistons 60 installed in the cylindrical block 40 are each allowed to conduct a four-stroke-cycle action, namely, a power stroke, an exhaust stroke, a intake stroke, and a compression stroke. The stroke actions of the pistons 60 are coordinated with each other in a manner that each piston 60 is allowed to alternatively deliver part of the rotational mechanical power to the output axle 100. More specifically, once the rotary combustion engine is started, when the cylindrical block 40 arrives at a first position (see FIG. 1), each cylinder bore portion 48b of two of the chambers 48 (being positioned opposite to each other as shown in the figure) and an associated piston 60 installed therein may access one of the spark plugs 30 to be ready for a power stroke. Referring to FIG. 2, when the cylindrical block 40 arrives at a second position, the associated piston 60 installed in each cylinder bore portion 48b of the two chambers 48 has substantially completed a power stroke to be ready for an exhaust stroke, thus gaining access to one of the exhaust ports 26. Referring to FIG. 3, when the cylindrical block 40 arrives at a third position, the associated piston installed in each cylinder bore portion 48b of the two chambers 48 has substantially completed an exhaust stroke to be ready for an intake stroke, thus being accessible to one of the intake ports 28. Referring to FIG. 4, when the cylindrical block 40 arrives at a fourth position, the associated piston 60 installed in each cylinder bore portion 48b of the two chambers 48 has substantially completed an intake stroke to be ready for a compression stroke. Referring to FIG. 5, when the cylindrical block 40 arrives at a fifth position, the associated piston 60 installed in each cylinder bore portion 48b of the two chambers 48 has substantially completed a compression stroke and may arrive at a subsequent spark plug 30 to be ready for a subsequent power stroke. Thereby, each piston 60 is allowed to conduct reciprocal movement along a respective cylinder bore portion 48b, which in turn drives a respective crank 52 to rotate integrally with a respective pinion 80 through a respective connecting rod 50, which in turn drives the cylindrical block 20 to rotate integrally with the output shaft 100 with respect to the engine block 20 being kept stationary, whereby the rotation of the pinions 80 causes the cylindrical block 40 together with the output axle 100 (see FIGS 1-6) to rotate with respect to the engine block 20 to supply a rotational mechanical power.

[0015] Although the rotary internal combustion engine described above is only shown with four pistons, more or fewer than four pistons are still permitted, as they may be installed in a cylindrical block with more or fewer chambers to achieve the purpose of the present invention. For example, as shown in FIG. 9, there are six pistons 60 respectively installed in the cylinder bore portions 48b defined in a cylindrical block 40' with six chambers 48; as shown in FIG. 10, there are eight pistons 60 respectively installed in the cylinder bore portions 48b defined in a cylindrical block 40" with eight chambers 48.

[0016] Referring back to FIG. 8, the rotating speed of the cylindrical block 40 can be controlled from a selection of the gear ratio of the toothed ring portion 20a and of the pinions 80, so that the rotary internal combustion engine does not need an additional speed-reducing device to provide a suitable rotation speed to a transmission input shaft of a vehicle or an electrical generator. Furthermore, the gear ratio may be selected in combination with a selection of the quantity of pistons 60, the dimension of the cylindrical block 40, and the spacing and locating of the exhaust ports 26, the intake ports 28, and the spark plugs 30, so that a rotational mechanical power of a desired rotational mechanical power from the output axle 100 can be obtained.

[0017] As a summary, the present invention has the following advantages:

(1) since the power stroke movement of the piston is mostly converted to a rotational movement of the cylindrical block 20, the impact caused by the power stroke can be reduced significantly, thereby increasing the life span of the combustion engine;

(2) since the power stroke movements of the pistons of the present invention are almost completely converted to a rotational movement of the cylindrical block 20, the rotary internal combustion engine of the present invention may produce a power output greater than a conventional reciprocal combustion engine, and thus the present invention can be fabricated in a smaller size and/or a weight for an equivalent power output, thus saving fuel; and

(3) since the rotary internal combustion engine of the present invention need not employ valves, including intake valves and exhaust valves as employed in the conventional reciprocal combustion engines, valve damage is eliminated.

[0018] Although the present invention has been described with a certain degree of particularity, it is understood that the present disclosure is made by way of example only and that numerous changes in the detail of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed.

Claims

1. A rotary internal combustion engine, comprising:

   an engine block (20) defining a cylindrical inner space (22) in which a toothed ring portion (20a) is attached with said engine block (20), said engine block (20) being connected with an output axle (100), said engine block (20) being installed with a plurality of spark plugs (30) and

defining a plurality of exhaust ports (26) and a plurality of intake ports (28) communicating with said cylindrical inner space (22); and

a cylindrical block (40) rotatably and snugly fitted in said cylindrical inner space (22), said cylindrical block (40) defining a plurality of cylinder bores (48) therein along a circumferential portion thereof, each of said cylinder bores (48) having a piston (60) received therein and being accessible to said spark plug (30), said exhaust ports (26), and said intake ports (28) upon rotation of said cylindrical block (40), wherein said piston (60) is pivotally attached with a connecting rod (50) which is pivotally connected with a crank (52) which is coaxially and pivotally connected with a pinion (80) which in turn meshes with said toothed ring portion (20a) of said engine block (40); whereby each piston (60) is allowed to conduct reciprocal movement action including a power stroke movement, an exhaust stroke movement, an intake stroke movement, and a compression stroke movement along one of said cylinder bores (48), which in turn drives said crank (52) to rotate integrally with said pinion (80) through said connecting rod (50), which in turn drives said cylindrical block (40) to rotate integrally with said output axle (100) connected thereto, the rotation of said pinion (80) causing said cylindrical block (40) together with said output axle (100) to rotate with respect to said engine block (20) to supply a rotational mechanical power output.

2. A rotary internal combustion engine as cited in claim 1, wherein said plurality of said spark plugs (30), said plurality of said exhaust ports (26), and said plurality of said intake ports (28) are installed at intervals around said engine block (20).

3. A rotary internal combustion engine as cited in claim 2, wherein each exhaust port (26) is arranged at a position following one of said spark plugs (30), each intake port (28) is arranged at a position following one of said exhaust ports (26), and thus being adjacent to a subsequent spark plug (30).

4. A rotary combustion engine as cited in claim 3, wherein when said cylindrical block (40) arrives at a first position, said cylinder bore (48) and said piston (60) installed therein accessing to one of said spark plugs (30) to be ready for a power stroke; when said cylindrical block (40) arrives at a second position, said piston (60) installed in said cylinder bore (48) has substantially completed a power stroke to be ready for an exhaust stroke, thus being accessible to one of said exhaust ports (26); when said cylindrical block (40) arrives at a third position, said piston (60) installed in said cylinder bore (48) has substantially completed an exhaust stroke to be ready for an intake stroke, thus being accessible to one of said intake ports (28); when said cylindrical block (40) arrives at a fourth position, said piston (60) installed in said cylinder bore (48) has substantially completed an intake stroke to be ready for a compression stroke; when said cylindrical block (40) arrives at a fifth position, said piston (60) installed in said cylinder bore (48) has substantially completed a compression stroke to be ready for a subsequent power stroke.

5. A rotary internal combustion engine as cited in claim 4, wherein the quantity of said spark plugs (30), the quantity of said intake ports (28), and the quantity of said exhaust ports (26) are the same, the quantity of either of which is half of the quantity of said cylinder bores (48) defined in said cylindrical block (40).

6. A rotary internal combustion engine as cited in claim 5, wherein the rotational speed of said cylindrical block (40) is determined from the gear ratio of said toothed ring portion (20a) of said engine block (20) and said pinion (80).

7. A rotary internal combustion engine as cited in claim 6, wherein the angular distance between one of said spark plugs (30) and a following exhaust port (26) is substantially twice of the angular distance between the said following exhaust port (26) and a following intake port (28), and substantially equals the angular distance between the said following intake port (28) and a subsequent spark plug (30) following the said following intake port (28).

8. A rotary internal combustion engine comprising:

an engine block (40) defining a cylindrical inner space (22) in which a central toothed ring portion (20a) is integrally attached with said engine block (40), a plurality of exhaust ports (26), and a plurality of intake ports (28), a plurality of threaded holes (24) evenly defined along a periphery of said engine block (40) and communicating with said cylindrical space (22) to respectively receive a spark plug (30) therein, said plurality of exhaust ports (26) being evenly distributed along the periphery of said engine block (40) and respectively corresponding to said plurality of spark plugs (30), said plurality of intake ports (28) being evenly defined along the periphery of said engine block (40) and respectively corresponding to said plurality of spark plugs (30), each of said exhaust ports (26) being arranged following

one of said spark plugs (30) whilst each said intake port (28) being arranged following one of said exhaust ports (26) and thus being adjacent to a subsequent spark plug (30);

a cylindrical block (40) rotatably and snugly fitted in said cylindrical inner space (22) of said engine block (20), said cylindrical block (40) having a circumferential portion and a central hub portion (44) connected with an output axle (100) and thus defining a ring-shaped recess (46) between said central hub portion (44) and said circumferential portion, said circumferential portion of said cylindrical block (40) defining a plurality of chambers (48) evenly distributed therealong, each chamber (48) including a crank-receiving space portion (48a) and a cylinder bore portion (48b) communicating with said crank-receiving space portion (48a) corresponding thereto;

a plurality of pistons (60) each pivotally attached with a connecting rod (50) corresponding thereto and respectively installed in the cylinder bore portions (48b) of said chambers (48), each connecting rod (50) being pivotally connected with a crank (52) via a crankpin (54) mounted in the respective crank-receiving space portion (48a) above a bottom portion of said cylindrical block (40) which defines said ring-shaped recess (46) and each said crank-receiving space portion (48a); and

a plurality of pinions (80), each being coaxially and fixedly mounted with the respective crank (52) by a pin (56), each pinion (80) being located below the bottom portion of said cylindrical block (40) to mesh with said central toothed ring portion (20a) formed integrally with said engine block (20); whereby each piston (60) is allowed to conduct reciprocal movement action including a power stroke movement, an exhaust stroke movement, an intake stroke movement, and a compression stroke movement, along the respective cylinder bore portion (48b), which in turn drives the respective crank (52) to rotate integrally with the respective pinion (80) through the respective connecting rod (50), which in turn drives said cylindrical block (40) to rotate integrally with said output axle (100) with respect to said engine block (40), whereby the rotation of said pinions (80) causes said cylindrical block (40) together with said output axle (100) to rotate with respect to said engine block (40) to supply a rotational mechanical power output.

9. A rotary internal combustion engine as cited in claim 8, wherein when said cylindrical block (40) arrives at a first position, each cylindrical bore portion (48b) of at least one of said chambers (48) and each associated piston (60) installed therein are allowed to access one of said spark plugs (30) to be ready for a power stroke; when said cylindrical block (40) arrives at a second position, each associated piston (60) installed in each cylinder bore portion (48b) of at least one of said chambers (48) has substantially completed a power stroke to be ready for an exhaust stroke, thus being accessible to one of said exhaust ports (26); when said cylindrical block (40) arrives at a third position, each associated piston (60) installed in each cylinder bore portion (48b) of at least one of said chambers (48) has substantially completed an exhaust stroke to be ready for an intake stroke, thus being accessible to one of said intake ports (28); when said cylindrical block (40) arrives at a fourth position, each associated piston (60) installed in each cylindrical bore portion (48b) of at least one of said chambers (48) has substantially completed an intake stroke to be ready for a compression stroke; when said cylindrical block (40) arrives at a fifth position, each associated piston (60) installed in each cylinder bore portion (48b) of at least one of said chambers (48) has substantially completed a compression stroke to be ready for a subsequent power stroke.

10. A rotary internal combustion engine as cited in claim 9, wherein the quantity of said spark plugs (30), the quantity of said intake ports (28), and the quantity of said exhaust ports (26) are the same, the quantity of either of which is half of the quantity of said chambers (48) defined in said cylindrical block (40).

11. A rotary internal combustion engine as cited in claim 10, wherein the rotational speed of said cylindrical block (40) is determined from the gear ratio of said toothed ring portion (20a) of said engine block (20) and one of said pinions (80).

12. A rotary internal combustion engine as cited in claim 11, wherein the angular distance between a spark plug (30) and a following exhaust port (26) is substantially twice of the angular distance between the said following exhaust port (26) and a following intake port (28), and substantially equals the angular distance between the said following intake port (28) and a subsequent spark plug (30) following the said following intake port (28).

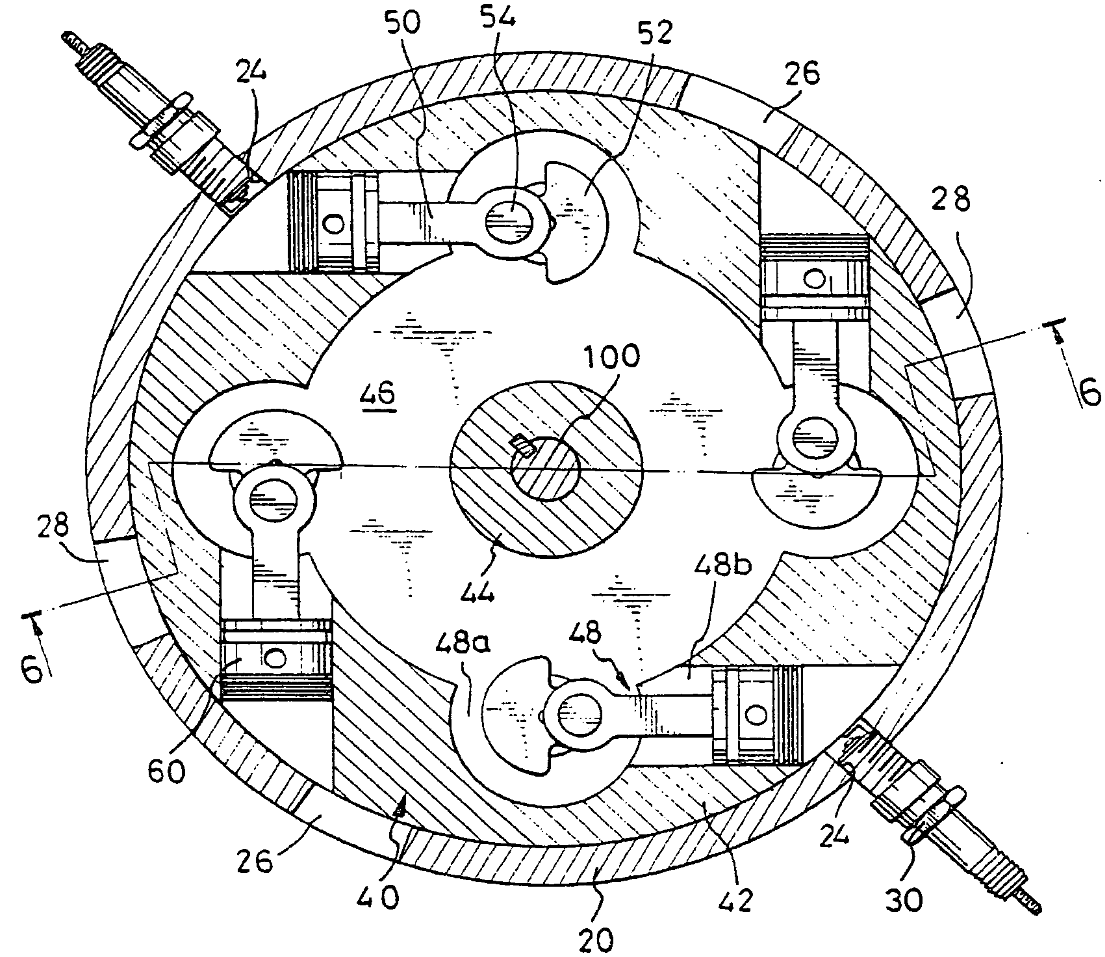

FIG. 1

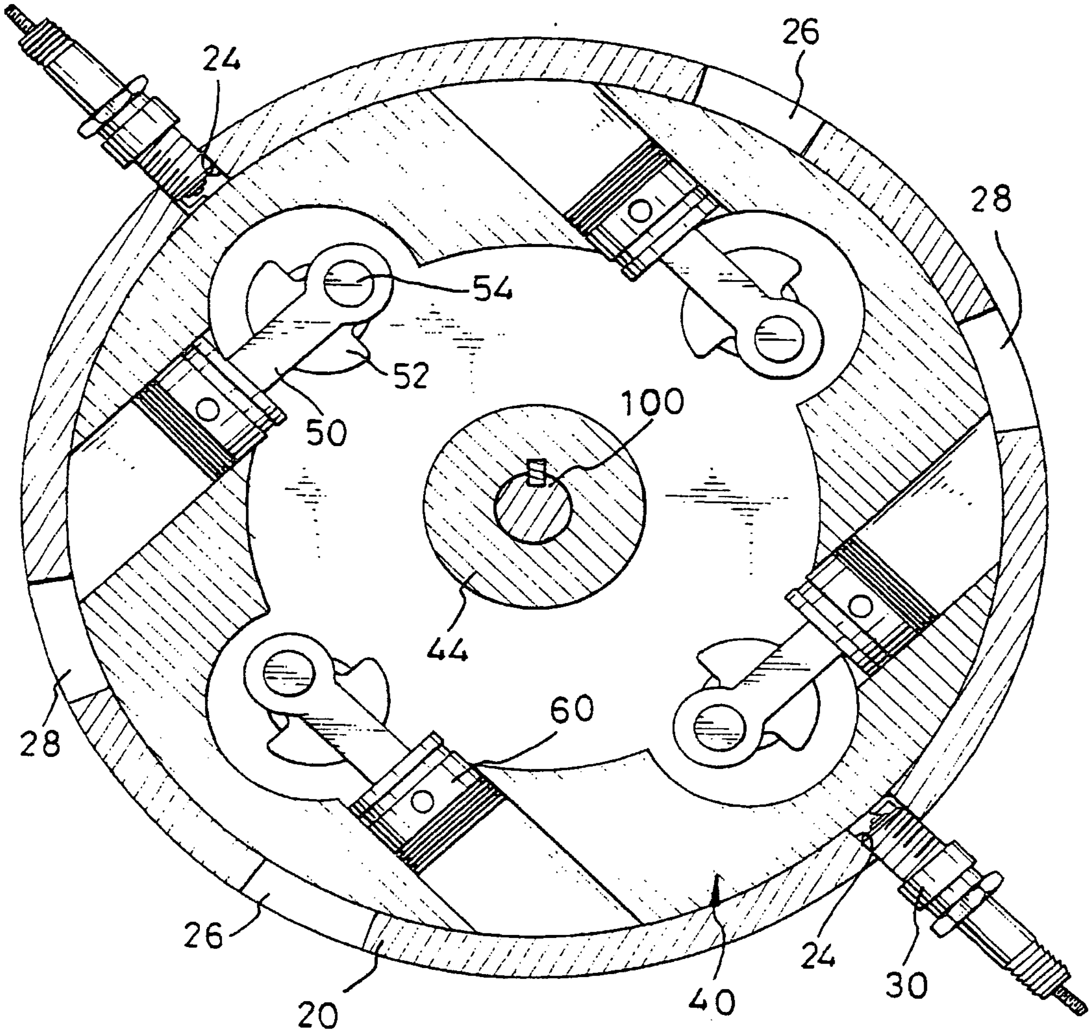

FIG. 2

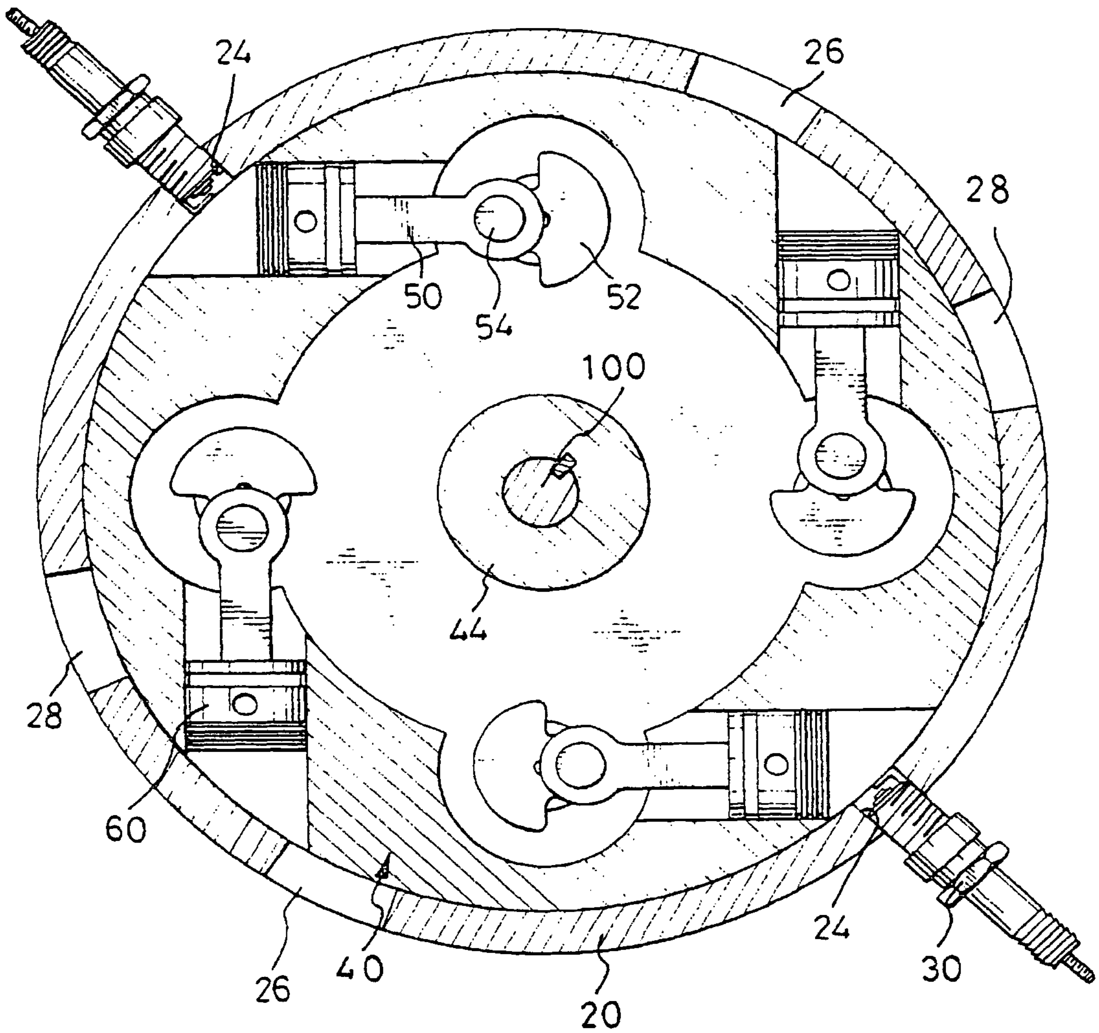

FIG. 3

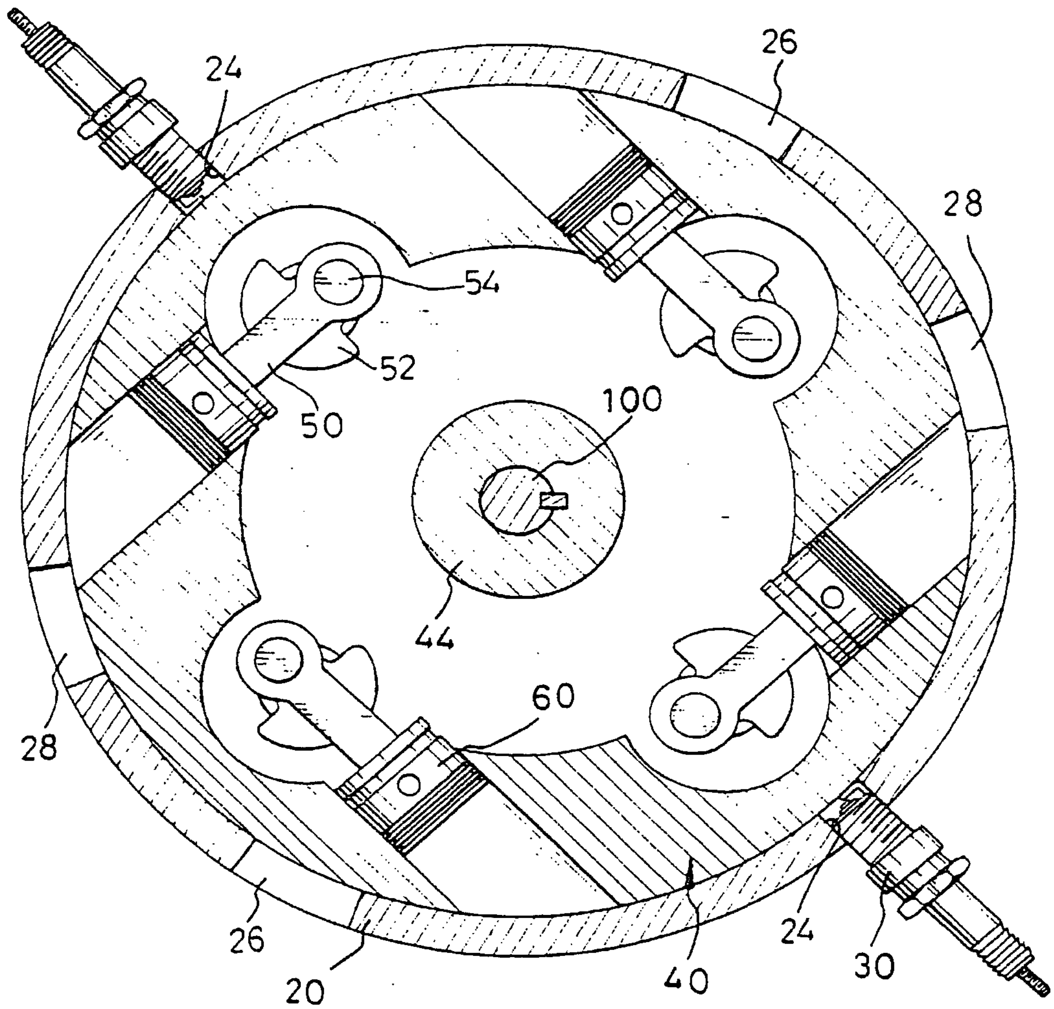

FIG. 4

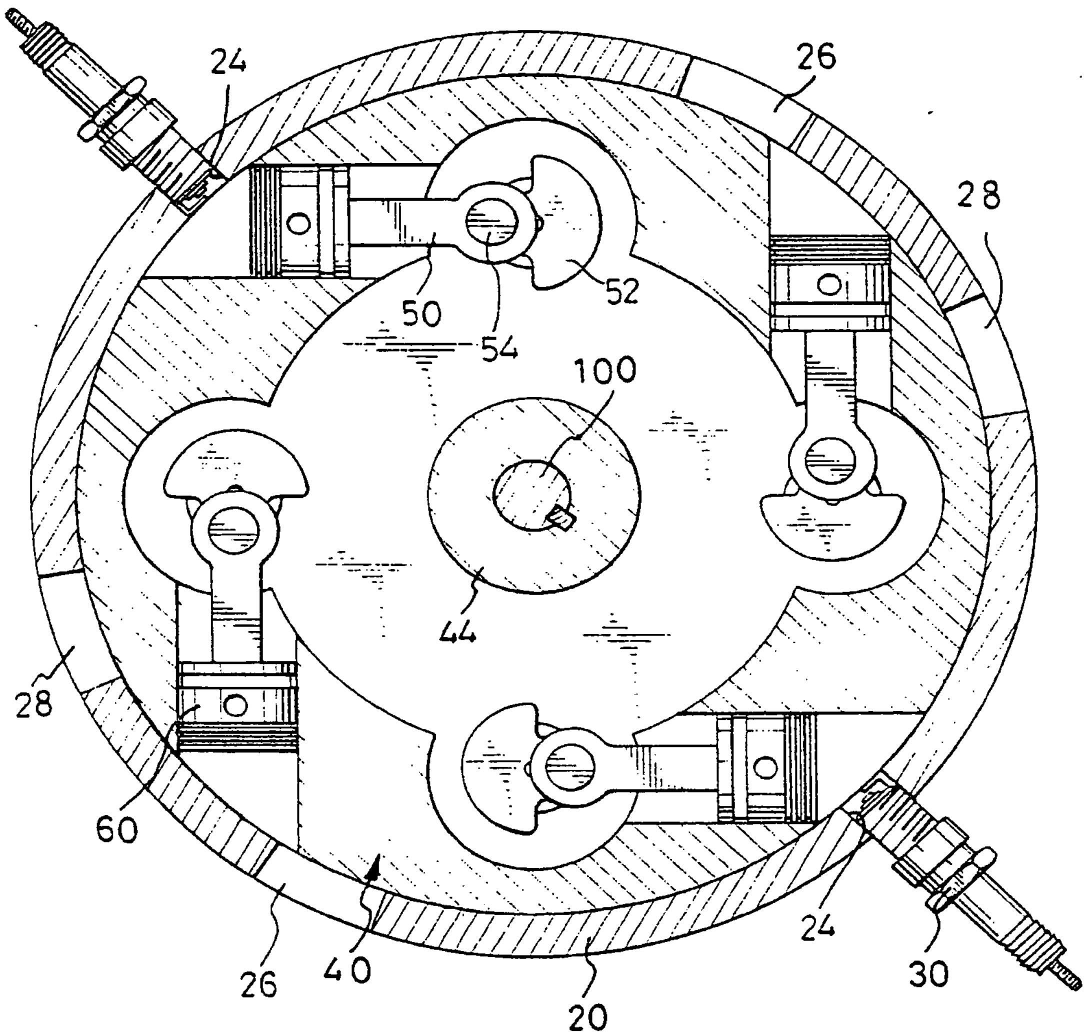

FIG. 5

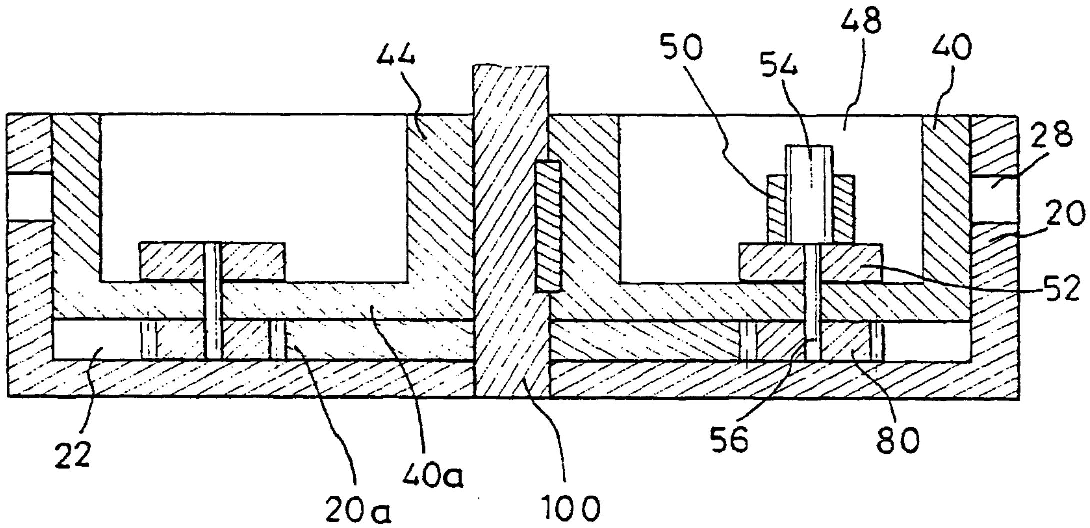

FIG. 6

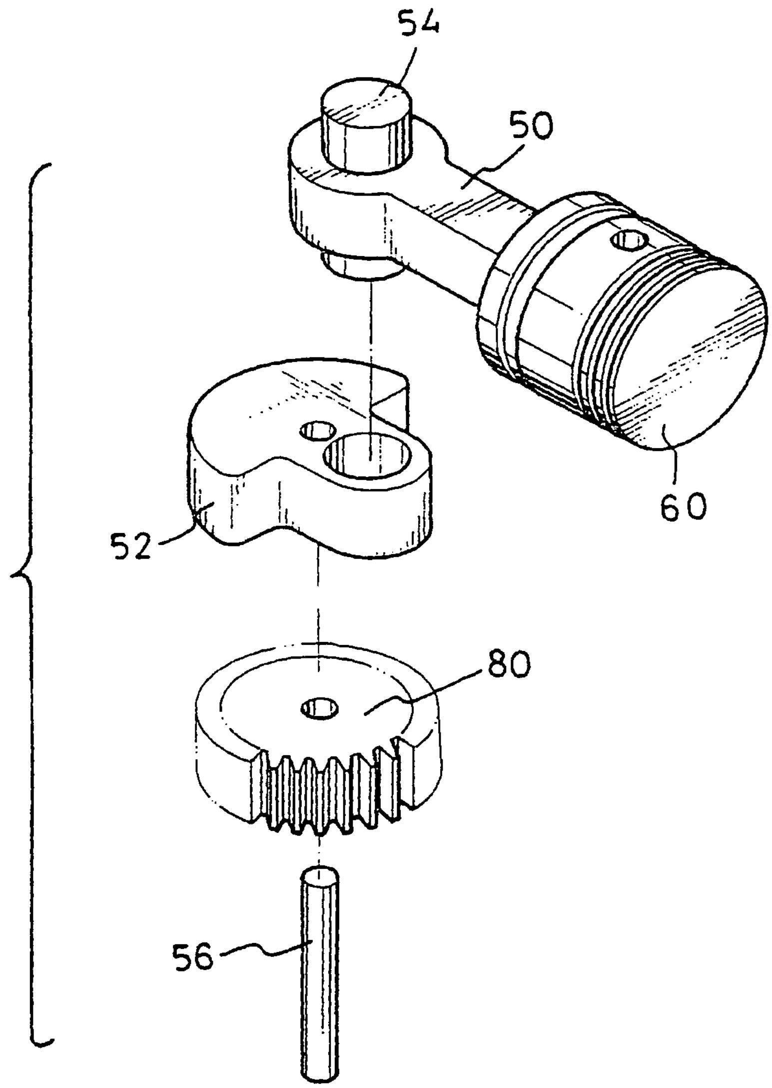

FIG. 7

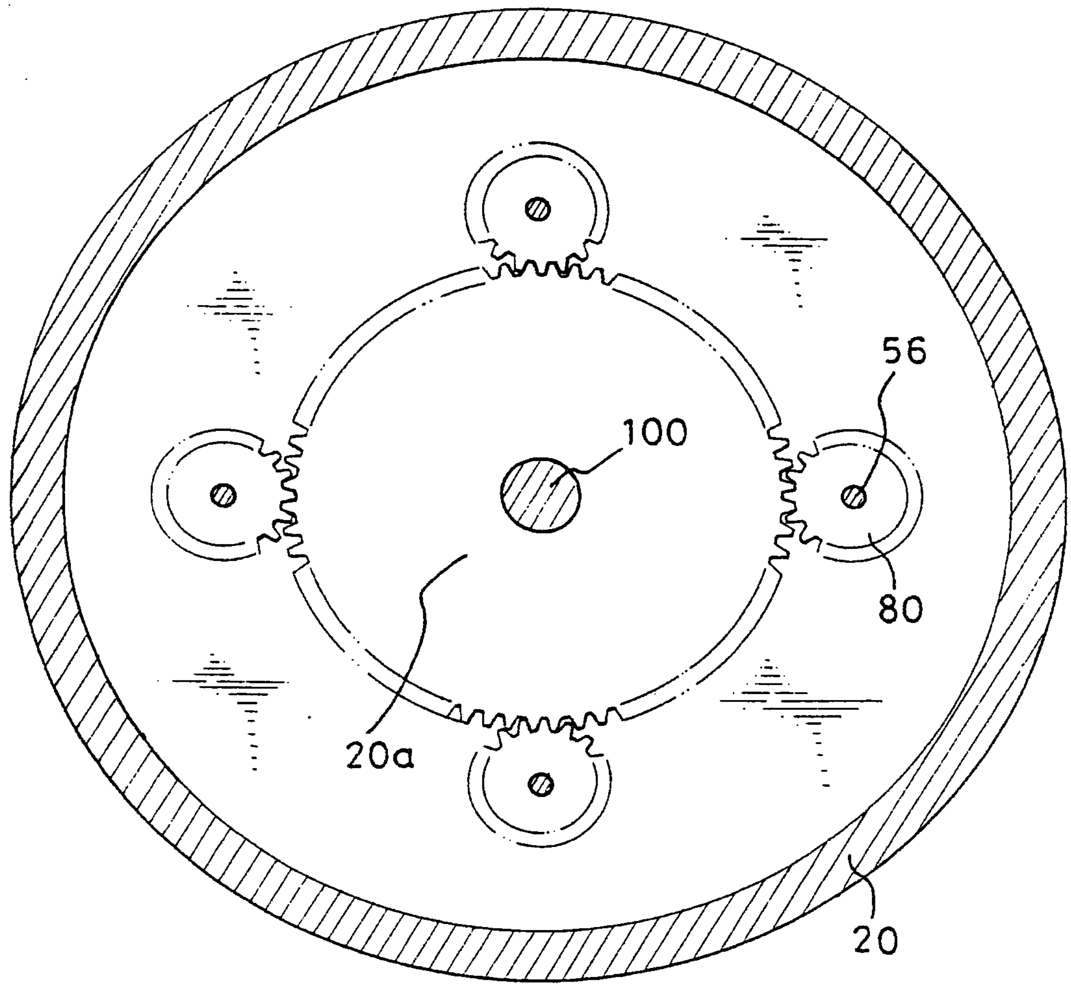

FIG. 8

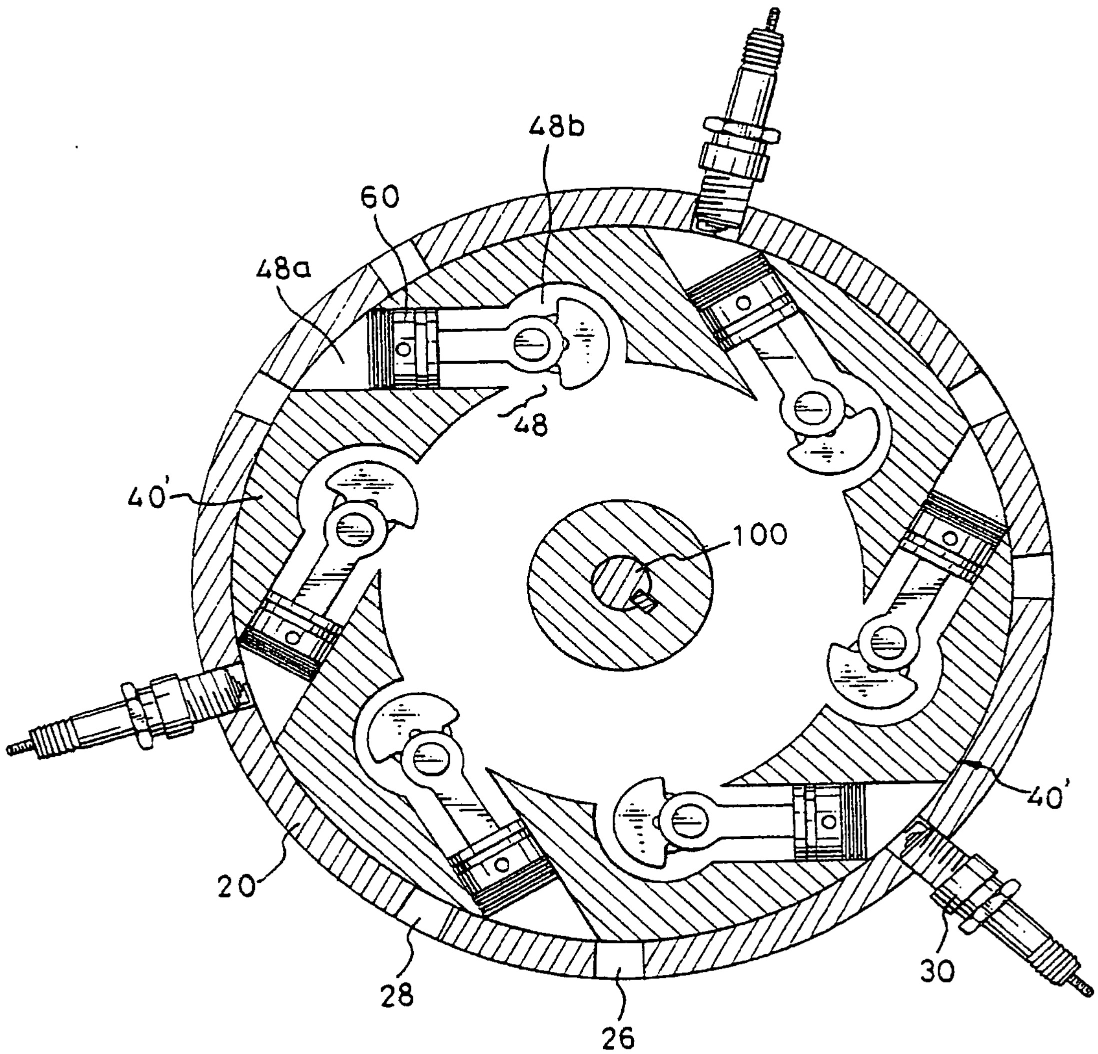

FIG. 9

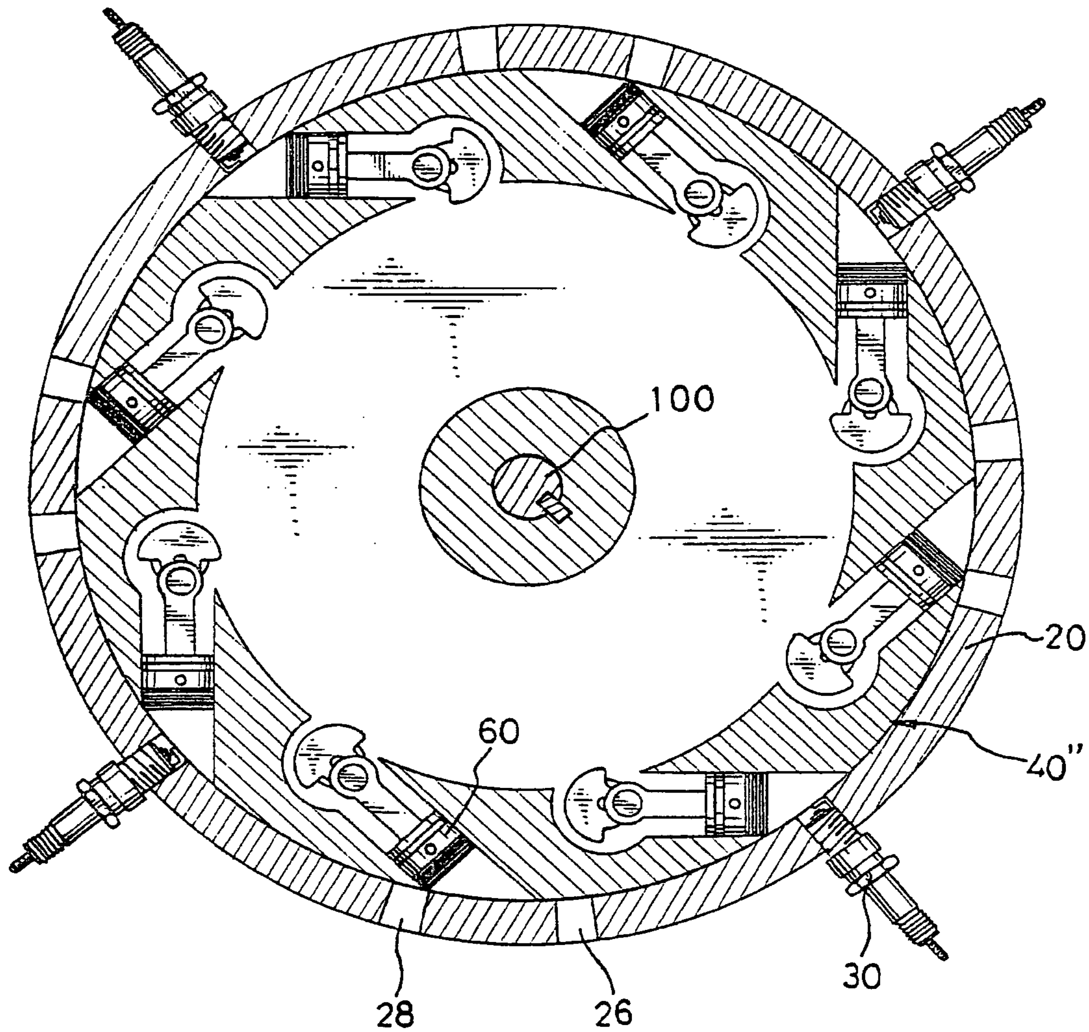

FIG. 10

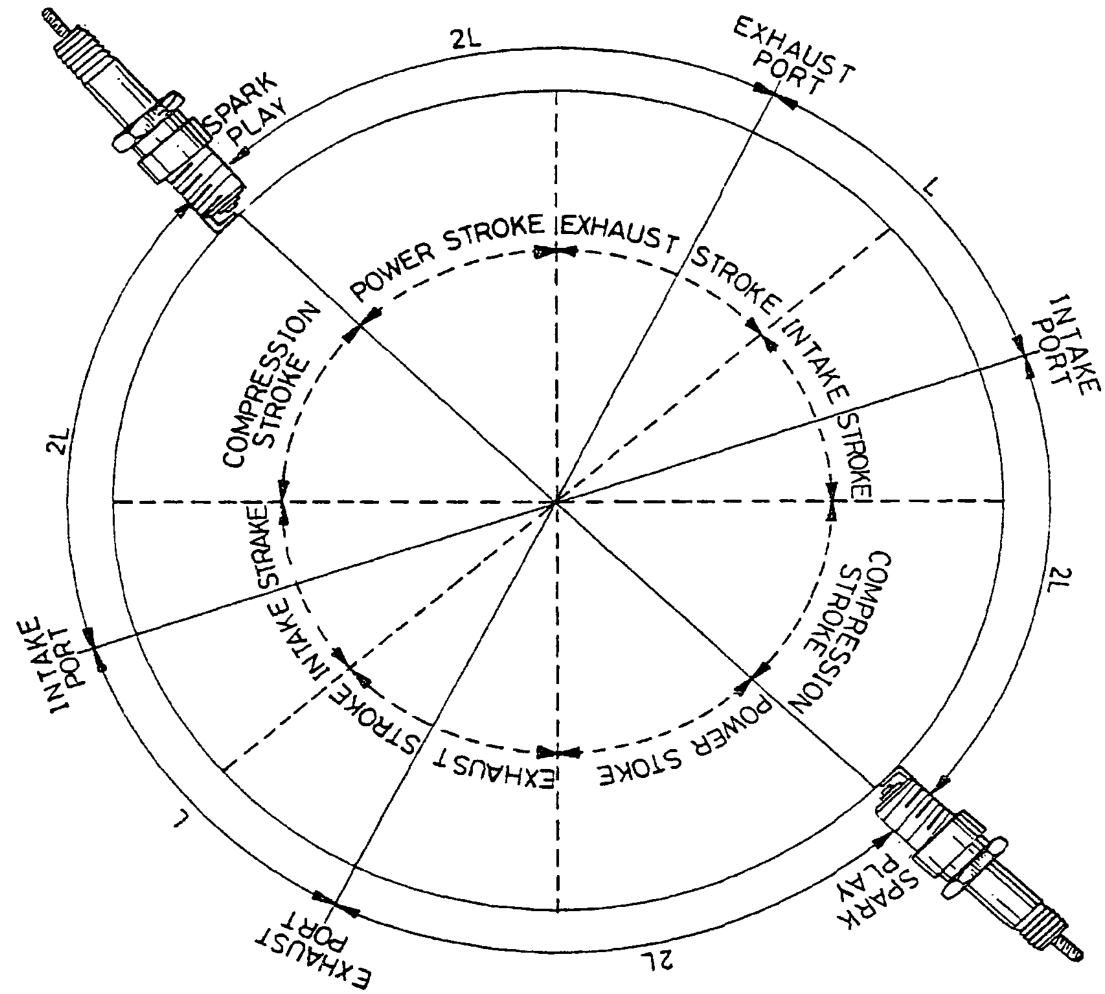
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FIG. 11

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 4564

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 2 990 820 A (GENZO SAIJO) 4 July 1961 * the whole document * ---	1-12	F02B57/08 F02B75/26
X	US 5 123 394 A (OGREN) 23 June 1992 * the whole document * ---	1-12	
X	DE 328 959 C (SCHWARZ) * the whole document * -----	1-4,8,9	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F02B
F01B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 November 1998	Kooijman, F

CATEGORY OF CITED DOCUMENTS

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